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Original Research Article

A cadaveric study of the Arcade of Frohse

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ABSTRACT

Context: Arcade of Frohse (AF) is the free aponeurotic proximal edge of the superficial part of supinator muscle. The posterior interosseous nerve (PIN) passes deep to it before entering supinator muscle. AF is the most frequent cause of PIN compression and radial tunnel syndrome. Knowledge of anatomy of AF is essential for surgeons while performing PIN decompression surgery.
Aim: To study the morphology and morphometry of Arcade of Frohse.
Settings and Design: The descriptive study was carried out in the department of anatomy on the cadavers that were routinely used for undergraduate education.
Materials and Methods: The AF was dissected out and studied in 60 upper limbs of adult human cadavers. Its shape and consistency were studied. The length, width and thickness of the arcade were measured using Vernier's callipers.
Statistical Analysis Used: All measurements were recorded in mm and analysed using range, mean and standard deviation.
Results: The shape of the arcade was semicircular in 13%, semi-oval in 17% and oblique elongated in 70%. The arcade was tendinous in 80% and membranous in 20%. The mean length, width and thickness of AF are respectively 13.1± 2.64 mm, 10.21± 2.57 mm and 0.43± 0.37 mm respectively.
Conclusions: Three types of morphology of AF have been identified based on the shape of the arcade. Tendinous AF was four times commoner than the membranous. The arcade had an average length, width and thickness of 13 mm, 10 mm and 0.4 mm respectively.

1. Introduction

Supinator muscle presents a superficial tendinous head and a deep muscular head, with the deep branch of radial nerve, also called the posterior interosseus nerve (PIN), passing in between. The superficial head bears a free arched proximal edge called the arcade of Frohse (AF).[1] This was first described by Frohse and Frankel in 1908 as quoted by Clavert et al.[2] Radial nerve entrapment in the arcade was first described by Kopell and Thompson in 1963 (mentioned by Ozturk et al.).[1]

The radial nerve divides into superficial sensory and deep motor branches proximal to supinator. The PIN passes through the musculo-aponeurotic furrow called the radial tunnel (RT) extending from the level of humero-capitellar joint to the distal edge of the supinator muscle. Five anatomical sites of compression of radial nerve in the RT have been identified, yet the AF is reported to be the most common cause.[2]

The arcade has been classified into tendinous and membranous types, based on the texture and constituent fibres. The tendinous variety is reportedly more liable to cause PIN compression and entrapment.[2] This condition is reported to be associated with elbow hyperextension, and repeated pronation and supination activities, as is observed in tennis players.[2–4]

Though several conservative management measures have been reported in literature, surgical decompression of the PIN is more promising in achieving good functional outcome.[1,2] Awareness of the anatomical properties of the

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arcade is crucial before contemplating surgical intervention of the radial nerve. There are no studies on the morphometrical parameters of AF in the recent past. Hence, this study was undertaken to throw more light on the morphology and morphometry of the AF.

2. Materials and Methods

The AF was dissected in 60 upper limbs of formalin-fixed human cadavers using the Cunningham method. The AF was studied in the supine position of the forearm. Variations in the shape of AF were noted. The consistency of fibres were studied based on the classification given by Prasartritha et al. in 1993.[5] AF was considered to be tendinous if both medial and lateral halves had fibrous texture, and membranous if the medial half of AF was muscular.

Dimensions of the arcade [width, length and thickness] were measured using the method employed by Ozturk et al.[1] The superolateral end of AF was considered as the proximal tip [PT] and the inferomedial end was considered as the distal tip [DT]. Two vertical lines are drawn, passing along the PT and the DT. Distance between the two lines at PT was considered as width [W] of AF, i.e horizontal distance between PT and meeting point 1 (MP1). Another horizontal line was drawn at the point of maximum convexity of the arcade. This line cuts the vertical line through PT at meeting point 2 (MP2). The vertical distance PT to MP2 was taken as the as length [L] of AF. Another line is drawn perpendicular to midpoint between PT and DT. Thickness was measured at the point (Thickness point TP) of intersection of this perpendicular line with arcade [Figure 1].

All measurements were taken using the Vernier's calipers and were expressed in mm. Results were expressed as range, mean and standard deviation, and compared with those of previous studies.

3. Results

Based on the shape and arrangement of the superficial head of supinator, the AF was observed to be semicircular in 13% [Figure 2], semi-oval in 17% [Figure 3] or oblique elongated in 70% [Figure 4]. Tendinous AF [Figure 5] and membranous AF [Figure 6] were noticed in 80% and 20% respectively. The mean length of AF was 13.1 $\pm$ 2.64 mm (range 7.0 – 19.0 mm), the mean width 10.21 $\pm$ 2.57 mm (range 5.0 – 19.0 mm) and the mean thickness was 0.43 $\pm$ 0.37 mm (range 0.1 – 1.0 mm).

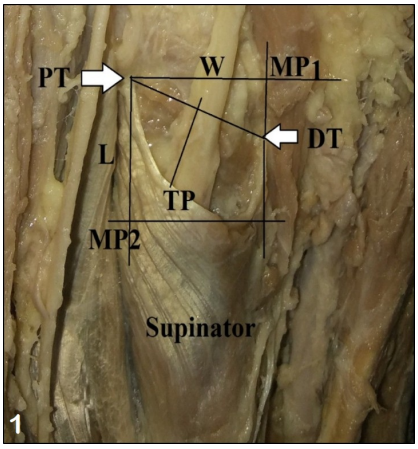

Fig. 1: Diagram to show measurements of length (L), width (W) and thickness of AF. PT – Proximal tip, DT – Distal tip, TP – Thickness point, MP1 – Meeting point 1, MP2 – Meeting point 2

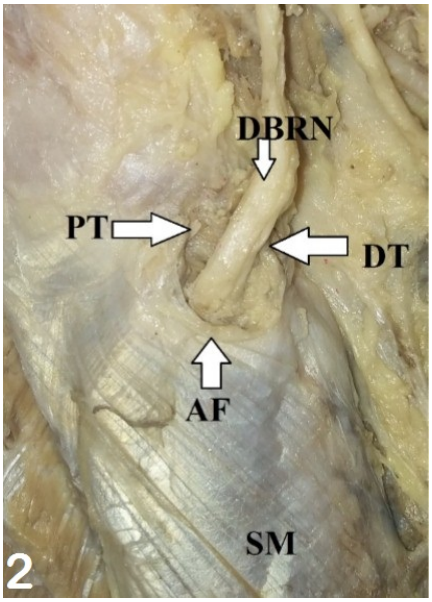

Fig. 2: Semicircular AF. DBRN – deep branch of Radial Nerve, SM - supinator muscle

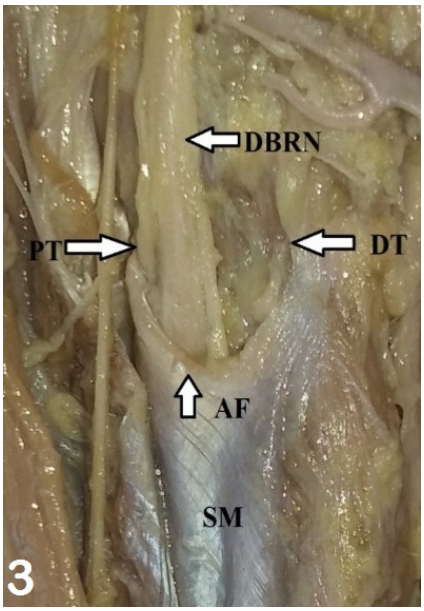

Fig. 3: Semi-oval AF. DBRN –deep branch of Radial Nerve, SM - supinator muscle

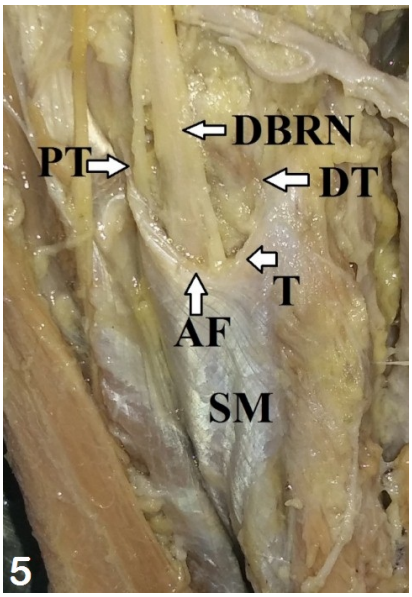

Fig. 5: Tendinous AF –indicated by arrow T. DBRN – deep branch of Radial Nerve, SM - supinator muscle

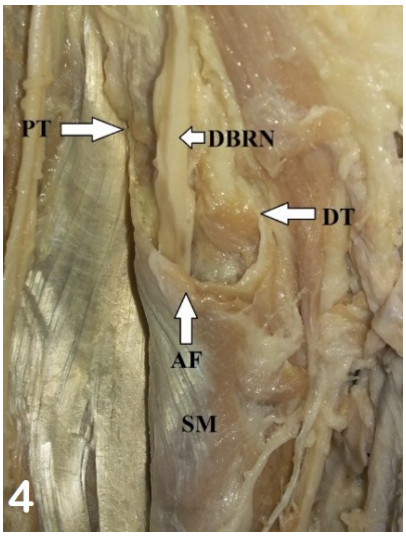

Fig. 4: Oblique elongated AF.DBRN – deep branch of Radial Nerve, SM - supinator muscle

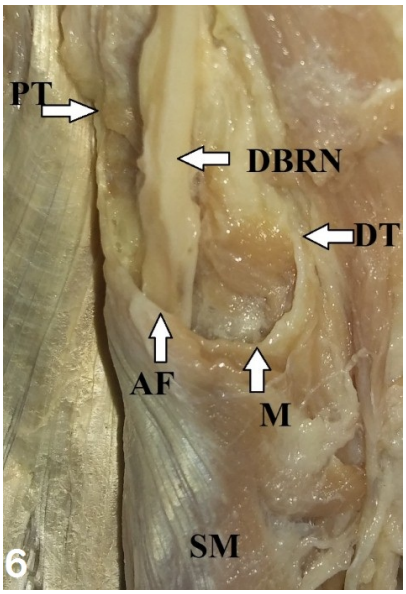

Fig. 6: Membranous AF - indicated by arrow M. DBRN – deep branch of Radial Nerve, SM - supinator muscle

4. Discussion

Intermittent compression of the radial nerve in the RT has been described at the following five sites: (a) fibrous bands tethering the nerve to the elbow joint, (b) arcade of Froshe (c) sharp tendinous medial edge of extensor carpi radialis brevis (d) Henry's leash of blood vessels arising from the radial recurrent artery supplying brachioradialis and extensor carpi radialis longus and (e) distal edge of supinator.[4] But the AF is the most common area causing compression neuropathy of radial nerve.[1–4] The incidence of PIN compression was estimated to be 0.03% in contrast to compression of superficial branch of radial nerve (0.003%).[6,7]

The AF has been described in literature as a semicircular proximal edge of superficial head of the supinator muscle. Clavert et al. and Ozturk et al. reported semicircular AF in all the specimens studied by them.[1,2] But we noticed the AF to be semicircular in only 13%, whereas semi-oval and oblique elongated AF was noted in 17% and 70% respectively.

The AF as reported first by Frohse and Frankel in 1908 was described as a normal tendinous structure present at the superior edge of superficial lamina of supinator (quoted by Ozturk et al.).[1] But subsequent literature described two varieties of AF, namely the tendinous and the membranous, based on the consistency of the fibres constituting the AF.[1,2,5] Review of literature shows highly variable percentage of tendinous AF (30% to 100%).[1,8,9]

In the present study, AF was found to be tendinous in 80% and membranous in 20%. This was similar to the findings of Clavert et al. in 2009,[2] Ozturk et al. in 2005[1] and Prasartritha et al. in 1993.[5] All three studies reported tendinous AF in 87% and membranous AF in 13%. Spinner in 1968 studied the AF in 25 adults and 10 full term fetuses (quoted by Clavert et al. and Ozturk et al.). He had reported absence of tendinous AF in all the fetuses studied in contrast to those in adult upper limbs. He postulated that the tendinous AF develops later in adults in response to repeated pronation and supination activities of the forearm.[1,2]

Tendinous AF is more likely to cause PIN compression especially when it is thick and presents a narrow passage for the nerve. Repetitive movements of pronation and supination causes PIN compression between two inextensible structures, namely the proximal end of radius (radial head and tubercle) and the tendinous AF. In supination, PIN moves laterally, lengthens and rotates, though superficial layer of supinator is relaxed. In pronation, superficial layer of supinator is tightened, compressing PIN passively.[10] Repeated constrictions of the supinator increases perineural pressure by five times, promoting progressive development of histological changes in radial tunnel content, including fibrosis.[2]

The morphometrical parameters of AF namely the length, width and thickness, were reported in only two studies, Ozturk et al. (2005)[1] and Ebraheim et al. (2000).[11] Clavert et al. (2009)[2] and Konjengbam and Elangbam (2004)[12] studied only the length of AF. The morphometric measurements of the present and previous studies are given in the Table 1.

Table 1: Comparison of morphometric measurements of AF with previous studies

	Mean AF length (mm)	**Mean AF width (mm)**	**Mean AF thickness (mm)**
Ebraheim et al. (2000)[11] n=20	18.6 (males)	12.8 (males)	0.8 (males)
	18.5 (females)	12.5 (females)	0.7 (females)
Konjengbam and Elangbam J. (2004)[12] n=46	41.0	-	-
Ozturk et al. (2005)[1] n=55	8.60±3.51	10.13±2.10	0.77±0.34
Clavert et al. (2009)[2] n=30	25.9	-	-
Present study n=60	13.1±2.64	10.21±2.57	0.43±0.37

The average length and width of AF in our study was lower than that observed by Ebraheim et al.,[11] but higher than that of Ozturk et al.[1] The mean AF thickness obtained in our study was considerably less compared to both the above studies. The mean AF length obtained by Kojengbam and Elangbam,[12] and Clavert et al.[2] was significantly higher than that of the present study.

Entrapment of sensory branch of radial nerve at the elbow is uncommon, while the deep branch, PIN is prone for compressive neuropathies resulting in two different clinical entities, namely the Radial Tunnel Syndrome (RTS) and the PIN syndrome (PINS). RTS presents with pain in the lateral elbow and dorsal forearm with no muscle weakness. It may or may not be associated with sensory deficits. EMG is invariable negative. Whereas the PINS is dominated by weakness of extension of wrist and digits. Pain is uncommon and EMG is positive.[3]

The PIN is commonly compressed in both RTS and PINS. The clinical picture of RTS is characterized by pain and absence of muscle weakness, questioning the cause of sensory manifestations in pure PIN compression. This is explained by the fact that apart from motor fibres, PIN contains Group IV unmyelinated afferent fibres carrying nociception from the wrist joint capsule, and also small myelinated Group IIa afferent fibres from the muscles. The Group IV afferent fibres in the PIN are responsible for carrying the pain sensation from the joint capsules, thus explaining the sensory involvement in PIN compression in

RTS.[3]

Non-traumatic paralysis of the PIN in association with multiple constrictive points on the main trunk of the radial nerve has been reported.[13] Entrapment of the nerve is believed to cause a dual effect by bringing about a local inflammatory reaction with simultaneous vascular compromise. This reduces the adaptability of the nerve to the mechanical stress caused by movements at the elbow. This results in non-traumatic paralysis of the nerve.[14]

RTS is clinically diagnosed by tenderness on anterior aspect of elbow 5 cm distal to the lateral epicondyle of humerus. Clinically pain is experienced on resisted supination of an extended forearm, and on resisted extension of middle finger.[7] But the PINS is essentially a motor phenomenon presenting as finger and thumb drop. Wrist extension may be weak, but there is no classical wrist drop since extensor carpi radialis longus and brevis receive their innervation prior to the compression site.[15]

Though RTS and PINS are clinically separate entities, the management essentially remains the same.[3,16] Although several non-surgical treatments such as rest, NSAIDs, injections and physiotherapy are reported to be of doubtful functional outcome, it is justified in undergoing them before surgery. Surgery could diminish pain and symptoms in 67 to 93% of patients completely. Concomitant release of superficial branch of radial nerve along with PIN release is reported to be more promising in restoration of the muscle functions.[3,17] In cases of entrapment neuropathy, neurolysis and decompression of the nerve brings promising results especially in patients less than 50 years old and a pre-operative delay of not more than seven months.[18]

Entrapment neuropathies involving upper limbs are reported to be common and often debilitating.[19] Though the incidence of radial nerve entrapment is much less compared to that of carpal tunnel syndrome (0.1%),[7,20] restoration of function of fingers and thumb in patients suffering from RTS and PINS is very essential. Knowledge of the AF is required for the surgeons contemplating on PIN decompression surgeries.

5. Conclusions

The morphology of the AF was variable and classified as semicircular, semi-oval and oblique elongated, the last one being the most common morphology observed. The AF was found to tendinous in 4 out of 5 limbs. The mean length, width and thickness of AF are respectively 13.1 mm, 10.21 mm and 0.43 mm respectively. Awareness of these parameters will serve a better edge for the surgeons contemplating nerve decompression surgeries in this region.

6. Abbreviations

AF – Arcade of Frohse; PIN – Posterior interosseous nerve; PINS - Posterior interosseous nerve syndrome; RT – Radial tunnel; RTS – Radial tunnel syndrome

7. Source of Funding

None.

8. Conflict of Interest

None.

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